Outline - Recent Work at JPL under MSREP

Advanced Flash Memories

- Includes multi-level flash technology
- Latchup

64-Mb DRAMs

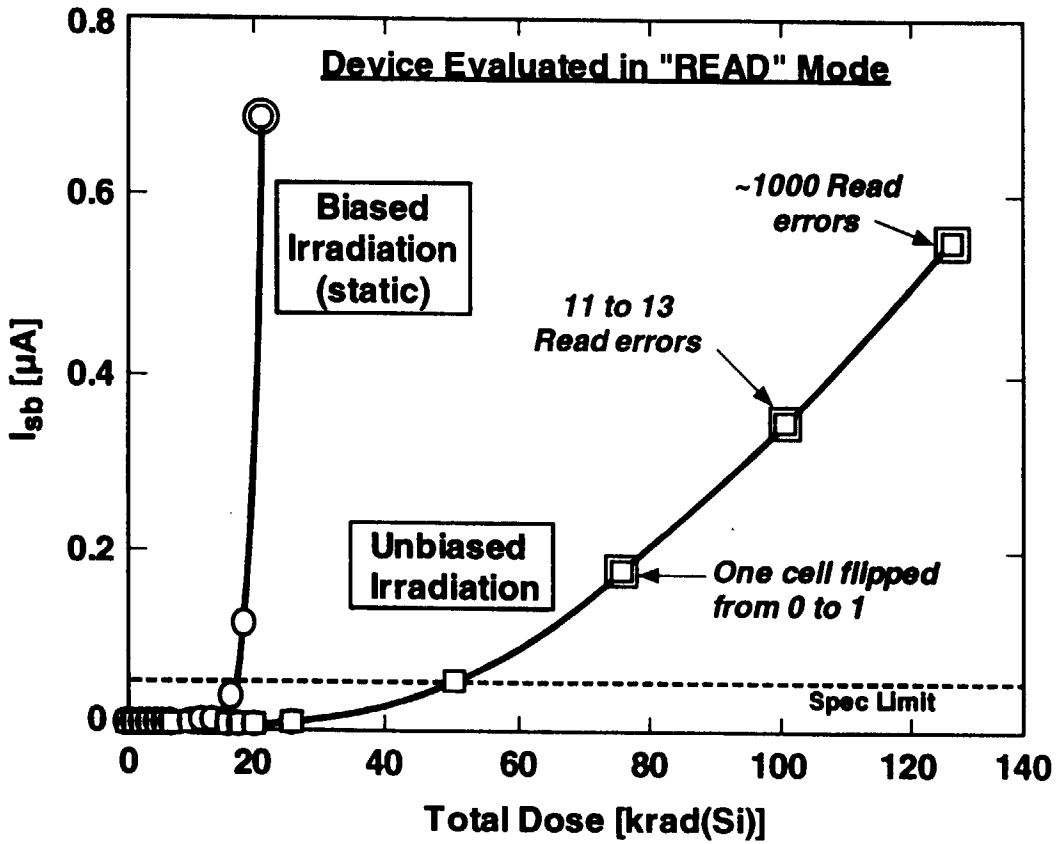
Displacement Damage in Linear Integrated Circuits

Optoelectronics

- Upset in Optocouplers
- Proton Damage in Light-Emitting Diodes

Hybrid Devices: Power Converters

Total Dose Degradation of Intel 64-Mb StrataFlash



Summary of Results for Advanced Flash Memories

Two Technologies

- Intel (NOR Technology with 3 Charge States)
- Samsung (NAND Technology)

Total Dose Degradation

- Different for READ and ERASE/WRITE/READ Modes
- Charge Pump Is Probable Cause of ERASE/WRITE Failure
- Newer Devices Similar to Older Flash Devices [8 - 15 krad(Si)]

Single-Event Upset Is Complex

- Devices Subdivided at Page Level
- Internal Controller, Buffers Easily Upset

Paper at 1999 NSREC

64-Mb DRAMs

High Interest at JPL because of Solid-State Recorders

Evaluated Devices from Three Manufacturers

- Parts Require Re-Packaging for SEE Testing
  - Lead frame extends over chip
  - Costly process
- Upset Cross Section Similar to Older DRAMs
  - Very low threshold (LET ~ 2 MeV-cm^2/mg)
  - No Latchup
- Multiple-Bit Upset far More Important for Advanced Devices
  - Severe issue for SSR applications
  - Limits effectiveness of EDAC
  - Upsets in decoding, sense amps also important

Analysis of MBU in Progress

Displacement Damage in Linear Integrated Circuits

Protons Produce Displacement Damage as well as Ionization

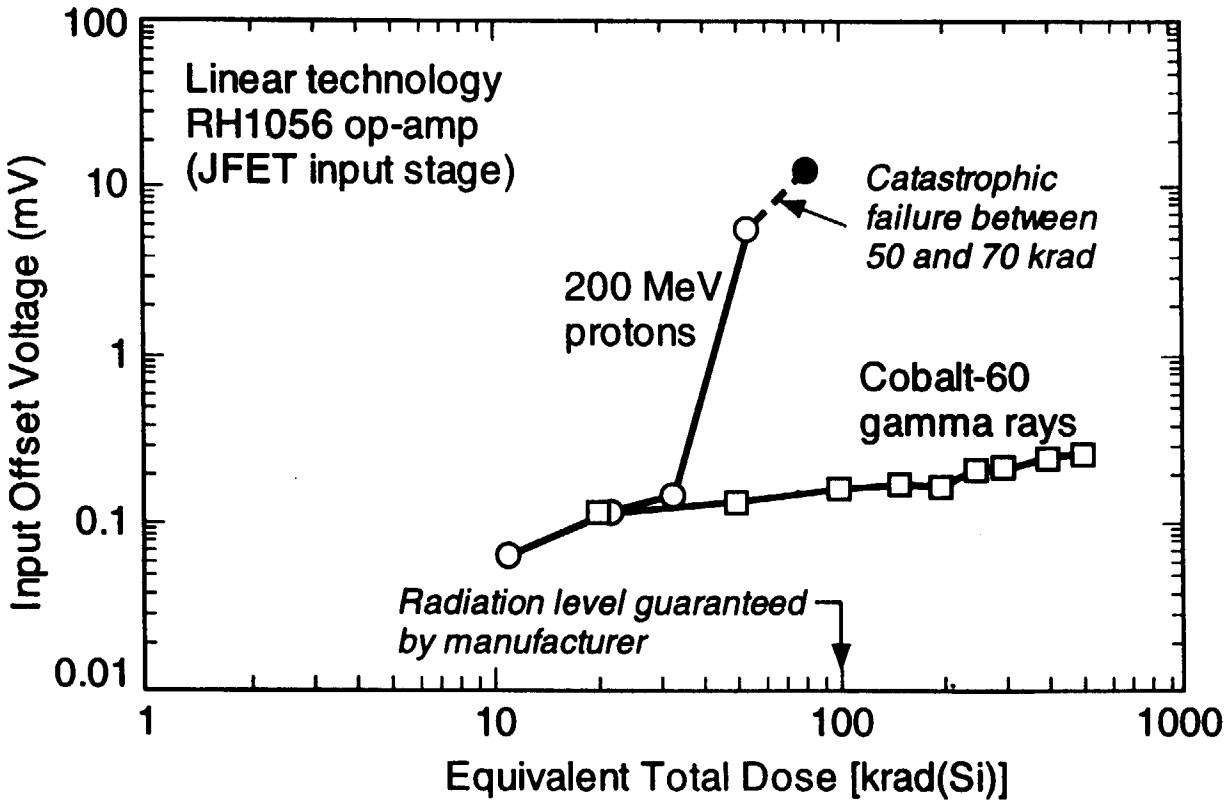
- Affects linear devices with lateral and substrate pnp transistors
- Net effect is superposition of ionization and displacement damage

Several Device Technologies Affected

- Op-amps
- Voltage regulators
- Some hardened technologies that use pnp transistors

Paper at 1999 NSREC

Example: Proton Degradation of a Hardened Op-Amp



Upset in Optocouplers from Protons

Cross Section Increases at Extreme Angles

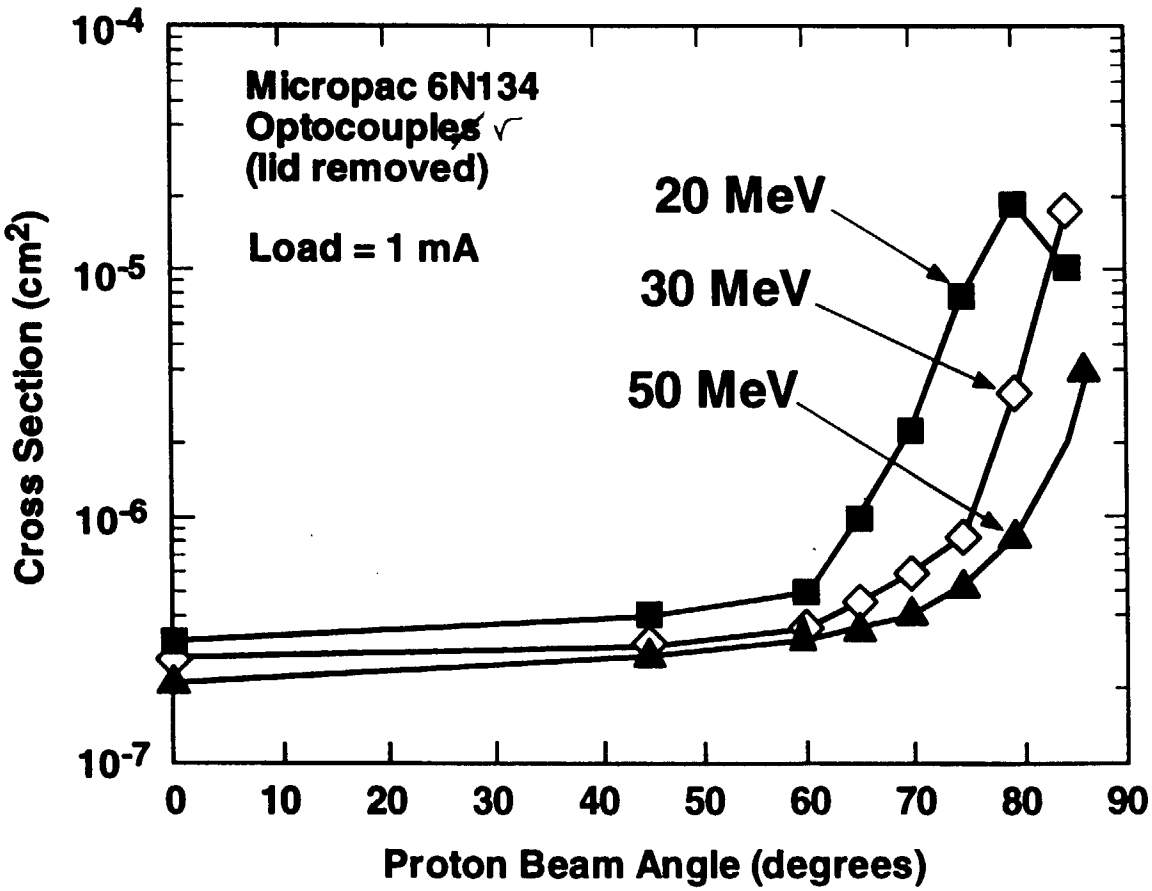
- First identified by GSFC (1997)
- Moderate increase at high proton energies
- Mechanism uncertain

New Results Show Large Increase at Less Acute Angles

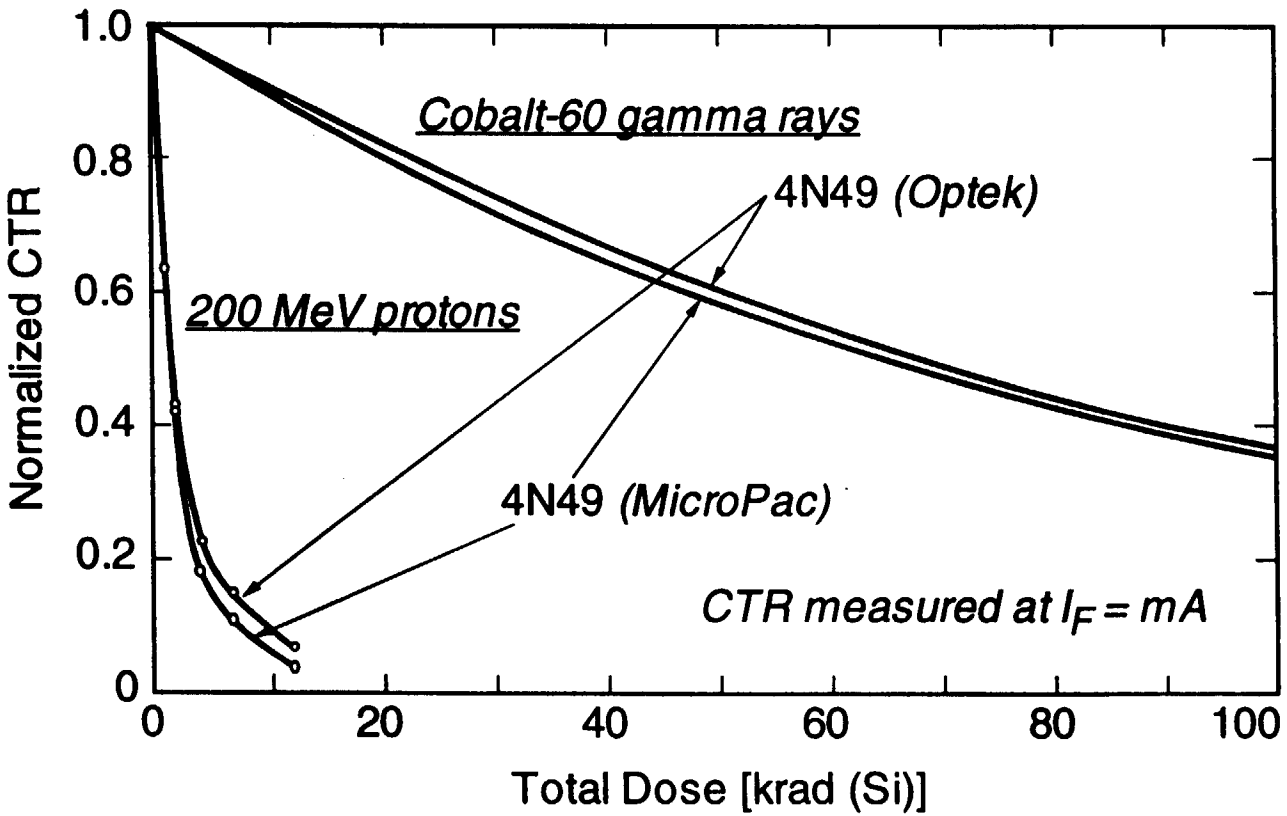
- Cross Section Increases by 100 at Low Energies
- Verifies Direct Ionization Mechanism in Photodiode
- Occurs because of Large Photodiode Area, High Sensitivity

Paper at 1999 NSREC

Effect of Proton Irradiation at Various Angles



Proton Damage in Optocouplers and LEDs



Work in Progress

Proton Testing of Several LED Technologies

- GaAs and AlGaAs LEDs Used in Optocouplers
- Other LED Technologies
  - Shorter wavelengths
  - Double-heterojunction devices

Development of Characterization Methods and Models

- I-V characterization and wavelength
- Injection-enhanced annealing

Papers at 1999 NSREC and RADECS99

Hybrid Power Converters

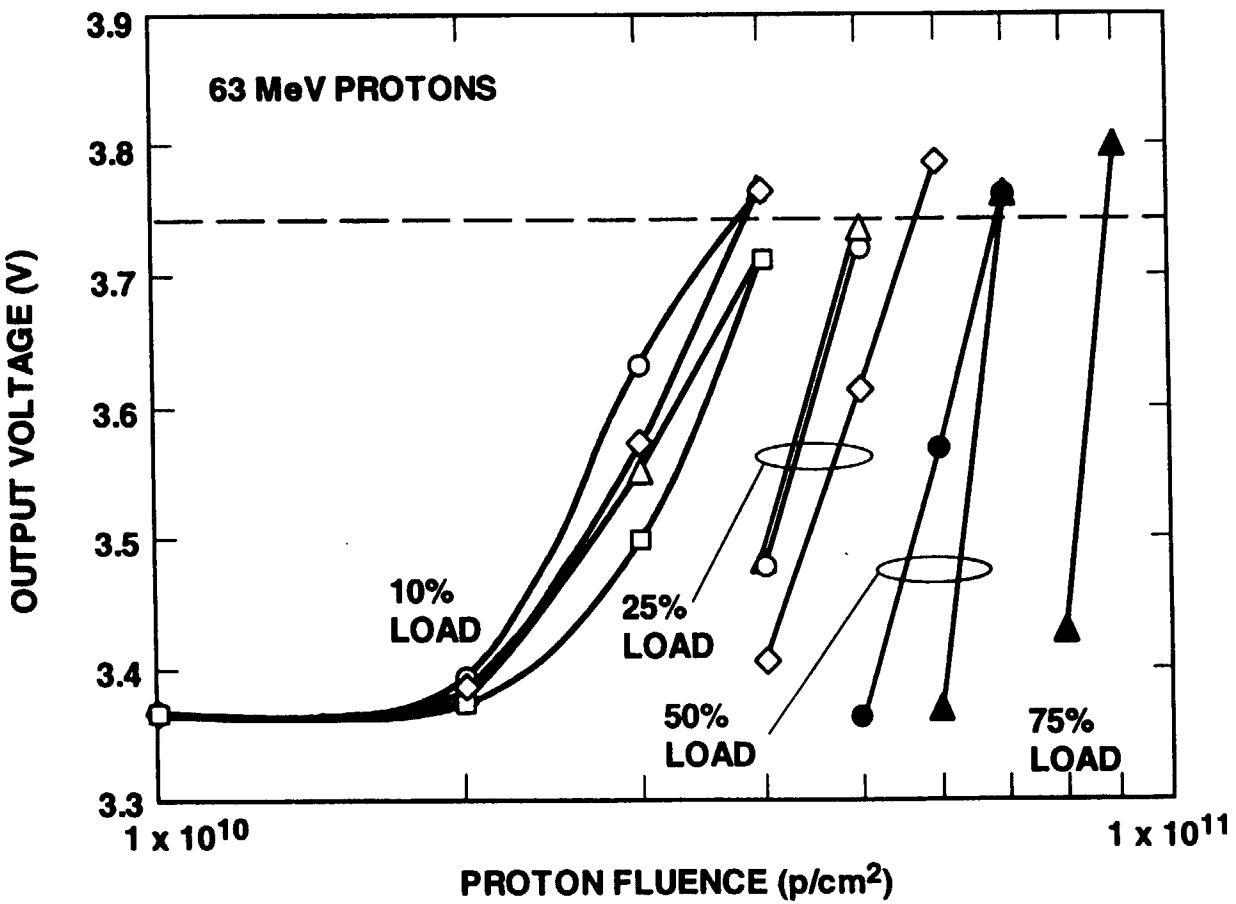
Several Important Issues

- Proton Degradation of Internal Optocouplers
  - Manufacturers changed optocoupler types
  - Illustrates problem of configuration control
- Dropouts from Single-Event Transients

Variability in Part Types and Suppliers Cause Major Problems

- Radiation Testing Limited to Small Samples Sizes
- Testing Must Consider SEE and Displacement Damage

Effect of Protons on MDI Power Converter



Summary

MSREP Is a Multi-Faceted Program

- Radiation Effects in New Technologies
- Development of Testing and Hardness Assurance Methods
- Continual Evaluation of Space and Laboratory Test Data
- Support to NASA Projects
  - Documents on new effects and technologies
  - Support for small projects
  - RADATA data base

Other Work in Progress

- Device Scaling and New Phenomena
- Radiation Effects in Microprocessors
- Latchup Testing and Latchup Mitigation
- Revised Radiation Design Approaches